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"Complexity concepts for Command and Intelligence"

Topic: C2 Concepts, Theory, and Policy

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Abstract

While it is generally recognized that an understanding of complexity is essential to the development of effective Command and Intelligence, there are no accepted, credible, models or metaphors to draw upon. This paper discusses the desiderata for such models and metaphors emerging from current work on command battlespace management (CBM) and ISTAR, describes a tentative model of complexity based on a school playground, and gives some deductions for the nature of uncertainty, collaboration, adaptation and consideration of effects, with particular attention to the implications for all-source intelligence problem analysis, multi-hypothesis testing, target identification and classification.

Keywords: Complexity, uncertainty, Holism, openness, adaptability, analysis.

Aim

The aim of this paper is to provide a metaphor for Command and Intelligence to show how it is often necessary to 'balance' or 'juggle' issues across different 'levels of the fight', or between conflict and confrontation, focusing on key issues while at the same time keeping one's eye on the 'bigger picture', and having the 'cognitive agility' to be able to switch from fight to fight or confrontation as circumstances occur, either to avoid being caught out or to exploit an emergent opportunity. It is intended that this metaphor will make clear the drawbacks of focusing exclusively on the apparent problem, and the need to select approaches and methods that are appropriate to this wicked type of nested problem-of-problems.

Introduction

Modern technology has the potential to transform combat, provided that our warriors are selected or adapted to suit. Or: A Colonel from the Western Front of 1918, after a morning's briefing on the capabilities of modern equipments and soldiers, could take command of modern forces, adapting modern equipment to his ways to great advantage.

Here we take as a starting point the idea that an understanding of complexity is essential to effective Command, which seems to be broadly accepted. Further, it is supposed that the science matters, a view that may not be universal within defence, but which seems accepted within the ICCRTS community. A point which seems at issue is the kind of science that is needed. The science that is being reflected in current equipments (and lately, concepts and doctrine) is quite different from that which informed previous generations of warrior. So our previous paragraph raises a key question: which ideas are more appropriate to modern defence?

The ideas reported on here do not reflect those of anyone other than the author, who has previously taken the controversial view that since the end of the Cold War our headline problems in defence have been of a kind which tend to highlight the inadequacies of the Cold War approach to defence science, and the need for the adaption of those sciences that are fit for our more complex purposes. Moreover, there seems to be no evidence that the fundamental scientific approach of previous science advisers (e.g., Bernal) are lacking. They simply need adapting and communication to fit current circumstances. It certainly seems clear that a science adviser from previous generations, looking at our situation today, would have much to say: to our advantage.

Lacking such wide-ranging insights, this paper briefly summarises relevant extant material and develops a tentative model of complexity. To demonstrated the utility of the model, it goes on to give some deductions for collaboration, adaptation and consideration of effects, with particular attention to the implications for all-source intelligence problem analysis, multi-hypothesis testing, and target identification and classification. However, these are simply provided as topical illustrations. The key point is the need for a change to an approach that is both more appropriate and more truly scientific – genuinely pragmatic.

Background

The need

There is a recognised need for more agility in command and control. As previously reported (Marsay 2006) command was previously treated in a more liquid way than is currently the case, seeking to balance fluidity and cohesion, and this would seem to provide an enabling concept for agility. Generally, current C2 practice is to seek to identify requirements and then to use classical logic to engineer systems meeting them. This approach is flawed if the 'requirements' happen to be inconsistent with each other, or with some of the policy, technology or other solution constraints. Hence one should undertake adequate requirements analysis to ensure that the requirements are satisfiable and do not lead to contradictions.

In C2 we currently lack exemplars of agile C2 that we can lean on to validate our requirements, and the approaches used by previous generations of C2 seem too distant to be of much use. Unfortunately, we also seem to lack effective concepts of requirements analysis for C2 that is to cope with complexity.

Complexity as open-ness

A feature of liquids is that there is no conventional 'structure', an idea that clearly challenges conventional systems engineering. But more particularly, there are no natural domains or scales of analysis. Some recent work on complexity in connection with C2ISTAR (Marsay 2007) has shown that a key factor in complexity is this inability to 'bound' problems: complex problems, in this sense, are open problems that cannot be 'closed'. The same work has also shown how 'common sense' can be misleading when applied to such complex situations. The key is that sufficiently complex situations are not analysable as combinations of definite parts. They continually change, invalidating any definite understandings and requiring an on-going process of appreciation. There is an uncertainty principle at work, like that for adaptive systems: the more stable their past behaviour the less they are exploring their environment, and hence the more likely they are to change suddenly in the future – the calm before the storm.

C2 roles

We can think of C2 roles as, broadly, operator, expert or generalist (Jaques 1998).

The operator works in a definite way, and their work can be checked. They either operate correctly or badly. Efficiency and effectiveness are the same.

Experts, as envisaged here, are experts in some definite, bounded, domain. There is a sense in which we generally suppose they are more or less 'correct' with regard to their domain, but we accept that the domain is complicated (perhaps even internally complex) and often fast developing, and so there are no absolute methods or final determinations of 'truth', only state-of-the-art approximations.

Generalists aim to cope with a broad range of situations, as British Generals[1] are required to. Generalists are born or developed, but not trained.

Many C2 studies seem best fitted for systems to be used by operators and experts. Moreover, C2 itself seems to be regarded as a domain for experts, albeit one where the expertise has yet to established itself. (Hence the need for ICCRTS.)

In the above terms, the science advice that informed previous C2 was more of a generalist approach, with clear links to logic and mathematics that transcend particular disciplines, rather than being simply multi-disciplinary, involving all relevant experts. This raises two questions: are the development of C2 and the use of C2 either or both things that can be left to experts? Is there a role for generalists, and how does it relate to that of experts and operators? For example, is a military force simply to be a hammer, to be used to smash-through any complexity? Or is to be wielded by non-military generalists? Either case would avoid the need for our military to have to handle complexity, but shift the burden elsewhere.

To address these issues, we need some comprehension of what generalists are faced with, other than just 'the difficult stuff'.

[1] According to Jaques US Generals are experts not generalists. Doctrinally they have sufficient means at their disposal to dominate situations, so that they 'only' have to be expert in their use.

Desiderata for models and metaphors

Whereas conventionally it is considered to be 'good' for models to be comprehensible to the widest (least experienced) audience, and hence tightly bounded and constructionist or reductionist, here we look for something more complex, like the things being modelled, open and holistic, after Whitehead (1929). During the Second World War a group of defence science advisers (including Bernal) and others, originally inspired by (Smuts 1932), showed how the modern ideas applied across a wide range of activities, including the arts (Brumwell 1944), thus providing a wide range of metaphors. However, they provided a broad overview, and did not focus on the 'nested' nature of situations or on those corresponding elements of uncertainty emphasised by Keynes (1921) and Smuts (1926, 1932) following the lessons identified in the Great War.

In pursuing this agenda, below, Fuller and Mao's approaches seem very relevant. This brings to mind another consideration: that of avoiding a tendency to encourage Fascism.

Tentative metaphor

A school play-ground

Consider a school play-ground in which the games to be played, and even their rules, are not fixed[2]. Players may agree to play some specific games by some agreed rules, subject to them perceiving adequate outcomes, which may include abstract requirements such as fairness. There are natural 'games of games', concerning which games to play, which may be as important as the ostensible games. There is a balance to be struck: playing brilliantly at a game could lead to not playing it again. Similarly, one could think about international relations or academic life as kinds of games-of-games.

Principles

This 'game of games' could be unsatisfactory, with no games or rules being agreed upon, or with games being prematurely abandoned. To help reach mutually satisfactory outcomes[3] there may be high-level or 'abstract' rules or principles that are more widely committed to than specific games or rules and which help shape the possible games and rules, so that, for example, new rules may be seen as variations on old ones or as subject to 'rules about rules'. There could be a specific agreement on such rules, with an effective enforcement mechanism (such as a referee). Or, instead, players may simply have observed that others tend to stick to particular rules, and suppose that their compliance would help the overall situation to continue, to mutual advantage. In such cases the overarching rules would exist only as 'emergent properties (Whitehead 1929, Smuts 1926).

[2] The importance of metaphors, and particularly for such nested metaphors incorporating the complexity of games-of-games was highlighted on work undertaken by QinetiQ for UK MOD RAO [Research Acquisition Organisation], to be covered by technical report on '*the Development of Strategic SA* [Situation Awareness] *and EBA* [Effects-Based Approach] */ CA* [Comprehensive Approach] *Capability*, due end of February 2008.
[3] In the sense of a Pareto optimum, where no alternative would significantly benefit all players.

Balance

In the short run, prescriptive rules will give more predictable outcomes, with surer benefits. However, as Boyd's law notes, with more prescriptive rules there is less opportunity for players to learn how others would have exercised their discretion, and hence resilience in the face of the expected events that can't have been 'programmed' for by the rules (such as new players joining, or unseasonable weather). Thus, according to the principle of subsidiarity the rules should be as loose as possible, giving players maximum discretion for an acceptable risk of 'bad outcomes'.

Comparisons

Sensemaking

Much of the conventional decision-making literature pre-supposes that it is a 'good thing' to think that there is a relatively comprehensible situation to be aware of, or that effective decision making is dependent on making sense of what is happening[4].

In contrast, in a game-of-games, more intuitive players may do well without necessarily having a well-developed sense of situation[5]. They may even strive to create confusion as a strategy for gaining relative influence.

A key notion of sensemaking is framing (Davenport & Prusak 1997). Here it is supposed that for any definite situation a frame is used to moderate the interpretation of sense data so that it yields a sufficiently definite cognition of 'the situation' to inform decision making. For example:

> Recent work of the SAS-050 NATO Working Group has stressed that data, when placed in context such that it reduces uncertainty, becomes information, while information becomes awareness when it passes from information systems into the cognitive domain (a human brain). Humans, as individuals, actually hold awareness of situational information and combine it with their prior knowledge and mental models … to generate situation understanding, which includes some perceptions of the cause and effect relationships at work and their temporal dynamics. (Alberts & Hayes 2006. Also SAS 050 2006)

In a game of games, though, a current definite game would correspond to a frame, but there is often uncertainty about who is playing which games, and how games may transform, and hence there is often no definite frame. It may be only after events have developed that it becomes clear, retrospectively, which game was dominant. Thus we mirror the concern of information theory:

> One has the vague feeling that **information and meaning may [be like] … conjugate variables in quantum theory**, they being subject to some joint

[4] We tend to think of central planning as a bad idea, not because it requires the planners to make 'sense' of the situation, but because it corrupts them. But it may also be bad because it mitigates against sustainability (Smuts 1926).

[5] Many notable firms rose rapidly from nothing on the back of one good idea, with no obvious reliance on a definitive understanding of the prior situation.

> restriction that condemns a person to the sacrifice of one as he insist on having much of the other. (Shannon & Weaver 1963)

Military Intelligence

> The key to understanding the roles of and the relationships among battlespace entities is to **focus on processes that turn raw data into information, and information into knowledge**. (Alberts et al 1999)

In military intelligence at a given level, say operational, the existence of frame corresponds to having definite intelligence about the context, e.g. strategic. This is often not the case. More often, at least against adversaries who avoid stereotyped behaviours, the military situation is equivocal, with the interpretation of source & agency data both depending on the supposed overall situation and providing evidence against the particular possibilities.

Military viewpoints

> In war everything is uncertain and variable, intertwined with psychological forces and effects, and the product of a continuous interaction of opposites. (Clausewitz 1832)

This is unlike a definite game or puzzle, and more like a game of games in form. 'Boney' Fuller, after rising to be a Colonel in the Great War, wrote of military decision making:

> While technical thought or skill enables a man to deal with the same circumstances that he has met with before, **scientific thought enables him to deal with different circumstances** that he has never met with before. Clifford, quoted in (Fuller 1926).

Thus where technical skill allows one to develop proficiency at a given game, 'scientific thought' enables one to cope with new games including games within games[6]. Fuller describes this as a process as follows:

> Whilst the interplay between ideas is imagination, and whilst imagination is ceaselessly shuffling ideas to and fro and weaving them into all manner of designs, according to the object which at the moment in control of the mind, reason is simultaneously selecting these designs which, when fitted together, like the pieces of a puzzle, will make a complete picture of our intention. Once this picture is complete the will is released. (Fuller 1926).

Smuts, who as a Great War General had had to cope with greater complexity than had Fuller as a staff officer, noted:

> We should as far as possible withstand the temptation to pour this plastic experience into the moulds of our hard and narrow preconceived notions, and **even at the risk of failing to explain all that we experience we should be modest and loyal in the handling of that experience**. (Smuts 1926)

That is, we cannot always form a reliable view of the current 'rules of the game', but must cope with equivocality. Nor is this a passing concern:

[6] Not even science is much use against totally new games, whereas games within games tend to have some commonality, so that skills and insights gained in one may be re-used in another.

> Such operations also tend to highlight the **shifting overlap** that always exists in practice between the various levels, the **constantly evolving** nature of operational art, and the fact that the operational level is **not tied to a particular level** of command or even to location. (Kiszely 2005)

How like a game of games.

World views

These days, world-view (or 'Weltanschauung') is often confused with 'viewpoint', but of concern here is the 'way of viewing'. Thus radio-astronomers on different peaks may have the same world-view despite different viewpoints, while a visible-light and radio-astronomer have different ways of viewing despite having the same viewpoints. Of more concern, in considering C2ISTAR support to commanders, it seems that commanders often have different worldviews from their staff and those responsible for acquisition and development: more like that of mathematicians and the Chinese than of Western Engineers, say.

It has previously been suggested (Marsay 2006) that one should consider a more scientific approach to the development of C2ISTAR, rather than seeing it simply as a tool, but recent research (Marsay 2007) has suggested the need for an even more fundamental role for science in supporting commanders. From a British point of view such an agenda can be anathema, partly because of a cultural distaste for intellect, and partly because it reminds us of the agenda of the 1930s and its application by Hitler and Mao.

To make a more scientific approach to C2ISTAR palatable, one needs to identify a scientific world-view that avoids the pitfalls of the past. A good candidate would seem to be the views of Mao, but without his over-riding concern to protect the governing institution. (Broadly, then, that of the British World-War Cabinets, or of games of games within a school playground, with no overall control.)

Organisations

The expert is only concerned with their specific domain, and (typically) reason can be relatively formalised so that the suitability of a design can be verified (Jaques 1998). As in logic and mathematics, the intelligence usually lies in the imaginative part and in the prior development of the methods of reason. However, in pure logic and mathematics the difficulty lies in the lack of prior assumptions (or frame) against which methods could have been developed and assessed as fit for purpose.

The difficulty of the generalist, then, is that there is no 'given' domain or frame of reference, and hence no given rules of reasoning that may be relied upon. Everything must be subject to experience and judgement. Otherwise, one can only rely on enduring principles, not established practices. And it always needs to be born in mind that all principles, in so far as they are justifiable, are empirical and hence tentative.

Systems of systems and Systems Engineering

Wikipedia notes

> "The development of the field of game theory also provides a gloss on relating engineering to SoS. The analogy is to a "game of games". Everything is very bounded in game theory. But in the real world the game is never over. So game theory has a problem to extend its techniques to understand how to approach games where the rules change, and the game is open." (S Popper et al 2004)

These games of games are too complex to have an explicit common purpose. Arguably, if we gave a system of systems a common purpose it would become a system of sub-systems, and a common purpose is necessary for conventional systems engineering to be appropriate.

> "A fundamental characteristic of problem areas where we detect SoS phenomena will be that they are open systems without fixed and stable boundaries. This flies in the face of standard system engineering that first requires us to describe the boundaries of the system to be considered. Good solutions under SoS circumstances will often not be static designs, but rather must be processes that adapt to changing circumstances. The demonstration that you have found a good solution may not be an accurate prediction of performance coupled with a methodology that guarantees optimality or efficiency. Rather, one may need to demonstrate processes that have good asymptotic properties, and that can evolve to keep performing in unstable environments."

Deductions

Uncertainty

Prior to the Great War, it was common to suppose that uncertainty and probability were the same thing, albeit there were debates about the different types of probability theory[7]. However it was recognized by the War Cabinet (following Kant (1783)) that according to such a view those actions which had seemed to contribute the most to military victory and planning for peace were irrational, as a result of which Keynes (1921) and Whitehead (1929) developed their theories of uncertainty and process, which contributed to the development of modern science[8] (Marsay 2006) and the logic of scientific discovery (KR Popper 1959).

Cohesion

Classical theories assume that the whole of reality is underpinned by common laws, and in that sense coherent. Whitehead's process model is different, however. It has hierarchies of processes that have various regularities that suggest a fractal mosaic of fixed constraints or laws. That is, a patch-work of 'epochs', where each epoch is itself a patch-work. There is thus cohesion, without there necessarily being strict coherence[9].

[7] E.g., frequentist versus subjectivist.

[8] Kant noted, like Churchman (2001) that rational methods are poor at resolving uncertainty.

[9] Thus, to an actor within a process, there can be no absolute notion of effects, progress or measure, since one cannot be sure that the epoch one is in will last. Hence one has the law of

There is a relationship between the pieces and the whole of which they are a part, but it is not a classically coherent 'sum of parts': the whole is more than the sum of the parts, the excess being the 'emergent properties'[10].

The implications are most evident in quantum physics, which cannot be modelled in a classical coherent way, since many properties are emergent. Bohr supposes that societies can be thought of in a similar way. For example, an attempt to over-regulate a school playground could destroy the pupils' cohesion. This raises the question of whether coherence and cohesion are compatible in societies under stress, and which we should be seeking[11].

Collaboration

According to wikipedia "**Collaboration** is a structured[12], recursive process where two or more people work together toward a common goal", whereas according to the Concise Oxford Dictionary, it is enough for people to be working together. The underlying assumption of the Wikipedia definition seems to be that productive associations require common purposes, but in our metaphor the intentions could be to develop skills at specific games, impress specific people, get fit, make friends, develop influence, or just to 'stay in the game'. Thus any common purpose may be rather abstract, and possibly even emergent rather than deliberate. Lacking a clear common purpose, players have to make judgements about the 'health' of the overall game-of-games and their impact upon it. This is quite a different situation to organised games, where the organisation can be taken for granted.

> "The component systems must, more or less, voluntarily collaborate to fulfill the agreed upon central purposes." (Jaques 1998).

Adaptation

Adaptation is a process by which a thing becomes adjusted to its environment. In our metaphor, a player may develop their skills at the currently most common game, and that sense be adapted, only to find that its dominance of the game leads to dissatisfaction by others and hence the adoption of a new popular game. Hence what is adaptive for the actual current game may be maladaptive for the broader game of games. It is possible to be over-adapted.

Effects

Whenever one thing is an effect of a given cause, the likelihood of the effect must have been increased by the cause. But the notion of likelihood is relative to a situation, such as a definite game. But in a game-of-games there is no definite game to give a definite meaning to the likelihoods, and so the notion of cause and effect is problematic, relative

unintended consequences, where the effects of levers may be reversed and progress against one's chosen measures can actually prove counter-productive in the wider process.

[10] In recent years the term 'emergence' has been diluted to include classical consequences as well.

[11] Similarly, should we seek to cohere worldviews or viewpoints?

[12] This would seem to imply coherence and thus preclude creative emergence.

or conditional. At best one has to make some assumptions on which effects can be conditioned.

Implications

The nature of Command and Intelligence

Command is sometimes about solving clearly understood problems in sufficiently understood contexts, in which case Intelligence may be faced with solving well-posed questions in sufficiently understood contexts. But increasing complexity can face either command or intelligence, or both, with 'wicked problems' or 'messes'[13]. For simpler problems there is typically a 'correct', 'objective' answer, one can audit and measure performance, and the prime concern is with efficiency. But for wicked problems, the situation is quite different. The key, therefore, is to be able to characterise the overall situation, and its potential, in order to determine the appropriate approach to Command and Intelligence, and hence the appropriate staffing, organisation and support architecture.

For example, if an adaptive system under observation is exploring its situation and remaining viable, our concern is to track the system behaviour. But if the system has become maladaptive, and is not exploring enough, then we should be concerned with the potential for change. It is sometimes thought that this is impractical, but (Marsay 2007) often the change is not to something totally new, but to a new combination of situation elements. Hence some form of analogical thinking (empirically proven) is indicated, which is quite different from the more normal parametric estimation and tracking of STAR.

In relatively simple cases all-source intelligence problem analysis is largely a case of bottom-up data fusion feeding into information fusion, with data and information being put into a context that yields a reasonable interpretation which can then be cross-checked with other sources, to confirm it or otherwise. But more complex cases are more driven by hypothesis making and multi-hypothesis testing, and hence more top-down[14]. In general, information-theoretic considerations suggest that analysis should focused at the level at which the complexity is focussed[15], which may be tactical, operational or strategic. Similarly for broader Command and Intelligence[16].

Target identification and classification

We consider things to be targets, and certain of their characteristics to be of interest, not because of their intrinsic properties but because of their significance within some game. In conventional conflict the nature of the game is conventional, with only some secondary characteristic varying, so what makes a target a target and which

[13] http://en.wikipedia.org/wiki/Wicked_problems.
[14] This is the subject of current work by QinetiQ for UK MOD on Multi-Intelligence Techniques.
[15] E.g. Ashby (1960).
[16] This says nothing about where the command and ISTAR staff should 'sit'. For example, support may be provided by reachback. But if all the ISTAR for a theatre is co-located, one still needs 'a tactical focus' for tactical issues.

characteristics are of interest is relatively consistent between occasions. But more generally the identity, classification and characterisation of potential targets all depend on the nature of the game, which is often uncertain and changeable. This is challenging to conventional notions of data and information fusion.

Conclusions

It has previously been noted (Marsay 2006) that there are many insights and techniques used to support Command and Intelligence that fell into disuse during the Cold War and which might be revived to advantage. Thinking in terms of games, the World Wars were complex nested games, and these techniques were for playing a game that is situated within a wider game, or is a game-of-games. In contrast, the Cold War was a relatively simple game-of-games, so that most 'players' could see their game as relatively independent, and focus on it. Thus it was possible to adopt simplified techniques, in which effectiveness and efficiency were assumed to be aligned (Marsay 2006). But since the end of the Cold War, this has no longer been the case (e.g. Kiszely 2005). This suggests the need for better understanding of nested 'games-of-games', including nested conflicts and confrontations.

The school playground is offered as a metaphor, to assist understanding. The school playground contains games. It also provides the arenas for overlapping games about what games to play, and who shall play them. It has links out into the community and wider games. It thus has a complexity that seems to mirror that noted for defence operations. The lack of single overarching 'logic' is characteristic, and impacts upon the nature of command and intelligence required, particularly the nature of uncertainty, collaboration, adaptation and effects, and in particular for all-source intelligence problem analysis, multi-hypothesis testing, and target identification and classification.

It is suggested that all concepts, doctrines, techniques, tools, equipments and senior personnel should be developed and assessed against nested situations with at least as much complexity as a school playground. Instead of thinking of military action as occurring in three types in three adjacent blocks, we need to be thinking of the types of activity as more mixed-up and interacting, and hence complex. For example, in considering candidate theories of complexity one should ask whether they can be used to model a school playground, or just one aspect of the activity within it at a time. British doctrine is already broadly compatible with this thinking, as reflected in senior commanders actions, but this understanding has yet to impact on equipment. It is proposed that a neutral metaphor would have some hope of being applied across the breadth and depth of defence (and more), giving more chance of a critical mass of techniques, tools, equipments being established. There is already some enthusiasm for some of the general ideas presented in this paper, with practitioners from the broad UK defence community particularly emphasising the need to take account of the nesting of their problems within confrontation and conflict. The time would seem to be ripe for the development of some pilot areas where such, or similar, insights and approaches could be developed.

It may be that such an understanding of the nature of confrontation and conflict is more important than an understanding of contemporary means, so that a Great War Colonel really could teach us – and our adversaries - some useful lessons.

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